

OLD OPEN CLUSTERS AS TRACERS OF GALACTIC EVOLUTION

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1. Why (old) open clusters?

Open clusters (OC's) are important to study the properties of the Galactic disk, since they offer information on ages, both absolute and relative, and on the metallicity evolution, both in space and time. In fact, OC's are found in different regions of the disk, cover a large interval in age (from a few Myr to about 10 Gyr) and in metallicity ($Z=Z_{\odot}/20$ to supersolar). Moreover, their ages and distances are accurate, much more than for any other disk object like e.g., single field stars. Also, since OC's orbits do not generally take them too far away from their birthplaces, we may assume that their current position in the Galaxy is representative also of their original one, and that we are not smearing properties by mixing populations, always a problem when dealing with field stars.

To define at least a reliable ranking of the open clusters properties we need a large sample of objects whose age, distance and metallicity are accurately and homogeneously known: see e.g., Janes & Phelps (1994), Carraro & Chiosi (1994), Friel (1995), Twarog et al. (1997). These authors have tried to define such samples, but had to sacrifice something in the quality of the data, often taken from the literature, and not as excellent as attain-

able with today's means, and/or on the homogeneity of the treatment to get a sample as large as possible.

We have started a few years ago a project, admittedly ambitious, to build a homogeneous and statistically significant sample of clusters of various ages, metallicities and positions in the disk. We work only on new photometry taken by our group, or on literature data of comparable quality. The clusters' properties are derived using the synthetic colour-magnitude diagram method (Tosi et al. 1991). We compare the observed diagram to a grid of synthetic ones, generated from a series of homogeneous sets of theoretical evolutionary tracks by several authors. The comparison is based both on morphology (e.g., main sequence shape, red clump position, gaps, etc.) and on population ratios (e.g., the luminosity function). We have already applied this method to nine open clusters, ranging in age from 0.1 to about 10 Gyr (see Bragaglia et al. 1999 for a recent review), and we have data for ten more.

We plan now to turn to spectroscopy, in particular to high resolution, in order to get precise information on the clusters' metallicity.

2. What do we know about open clusters' metallicities?

Of all the OC's we have studied photometrically, four have the metallicity measured by high dispersion spectroscopy, the best technique to get reliable results, with uncertainties of less than about 0.1 dex in $[\text{Fe}/\text{H}]$ (see Gratton 1999 for a recent review). If we look at the whole sample of old OC's this is true for only 18 of the about 80 known. There are other ways to get the metallicity, like low resolution spectroscopy calibrated to high-res, as done by Janes and Friel (see e.g., Friel 1995; this allows uncertainties of about 0.15 dex), or Washington, UBV and DDO photometry (with uncertainties of about 0.2 dex). A little more than half of the old OC's sample has the metal abundance measured by at least one of the above methods. An interesting feature comes out of the comparison between metallicities measures by high-res spectroscopy and any of the other methods: they all underestimate $[\text{Fe}/\text{H}]$ by at least 0.1 dex on average (even if the individual values may be off by much more).

Apart from a possible systematic effect, does the technique used influence the derived general properties of the cluster sample? If we consider the old OC's we can study the existence of the radial metallicity gradient using metallicities derived by all methods. Figure 1 shows the different cases; at least part of the observed dispersion at all Galactocentric distances is real. If we determine the slope of the metallicity gradient we find values very similar to each other within the errors; they are indicated in Figure 1, and are of the order of $-0.1 \text{ dex kpc}^{-1}$. Notice the larger slope obtained for

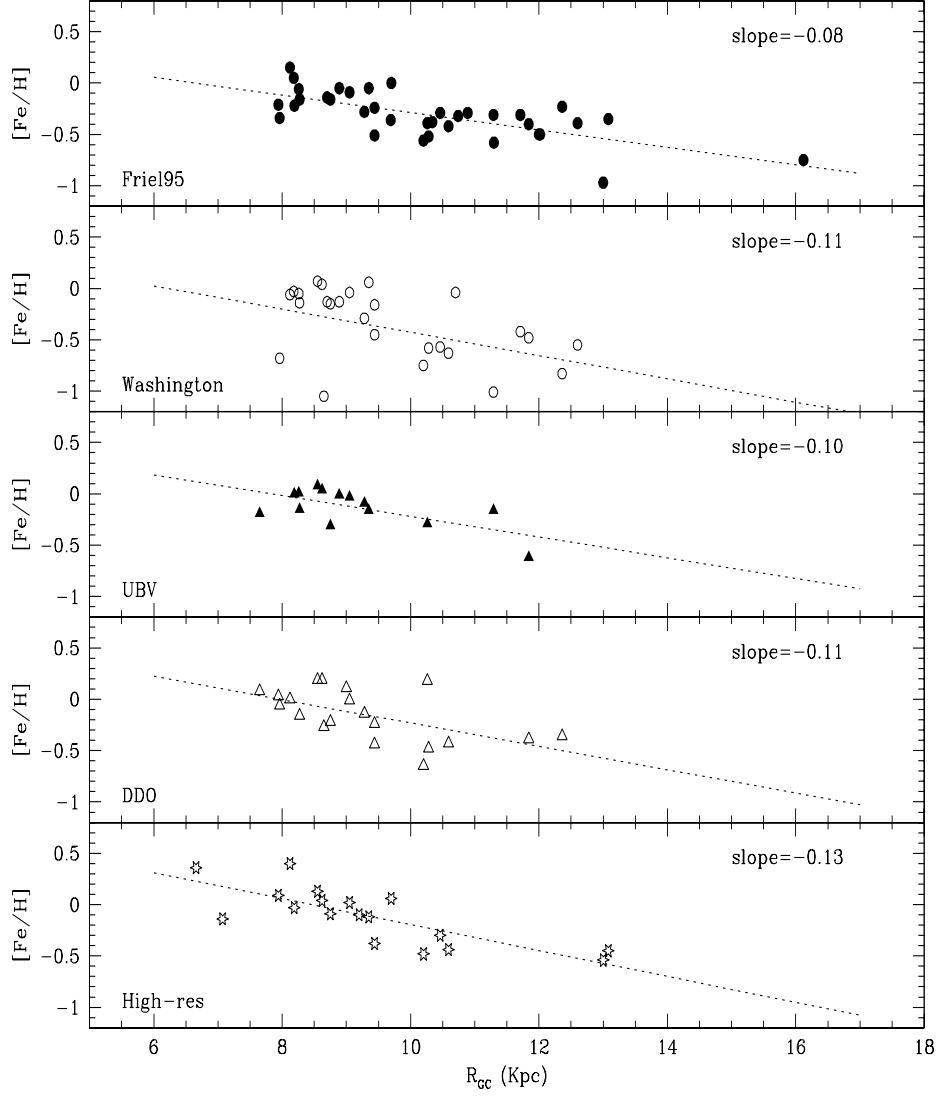


Figure 1. Old open clusters: run with Galactocentric distance of the observed metallicity, derived with different techniques (from top to bottom: by low resolution spectroscopy, by Washington, UBV, DDO photometry, and by high dispersion spectroscopy). The slope of the resulting metallicity gradient is indicated in each panel.

the high-res values; the sample is still too small to decide whether it is really significant, and it would be interesting to have many more high-res determinations to put on firmer grounds the absolute and relative values of OC's metallicities.

Regarding the slope of the radial gradient, it seems irrelevant which method is used to determine metallicities. On this basis, to study whether the metallicity gradient has changed with time, we use the Friel (1995) values, since they are the most numerous for the old OC's (36 OC's, compared to 26 with Washington, 14 with UBV and 20 with DDO photometry). If we divide the whole sample in four age intervals (age < 1, 1–3, 3–6, > 6 Gyr) we find that there is no variation of the gradient slope with age (see Figure 2). There may be a slight indication of a shallower slope for the younger OC's, but it's well within the errors.

Finally, using samples with metallicities obtained homogeneously, we do not see any indication of the discontinuity at R_{GC} about 10 kpc assumed by Twarog et al. (1997) as an indication of the edge of the original thick disk.

3. The metallicity of NGC 6253 and future work

Our first direct contribution to the knowledge of OC's metallicities comes from NGC 6253, a cluster in the direction of the Galactic centre, with age $\simeq 3$ Gyr, and metallicity solar or (more probably) twice solar as derived from photometry alone (Bragaglia et al. 1997). We have high resolution spectra of four giant stars, taken with EMMI mounted on NTT as part of a backup program in a night not suitable for photometry. As a result, the signal-to-noise ratio (about 35) and the resolution (about 15,000) are not as good as one would desire to derive precise abundances from fine analysis of high resolution spectra. This is especially true for stars of metallicity so high that continuum tracing is a very difficult task, and for this reason we compared the observed spectra with a field star of similar metallicity (ζ Cygni, $[Fe/H]=+0.05$), as shown in Figure 3.

On the basis of their radial velocities, all the four stars are cluster members. We have only studied the iron content of two red clump stars (see Carretta et al. 1999 for a more detailed description of the followed procedure), and derived for them the following values: #2971: $[Fe/H] = +0.33$, and #2508: $[Fe/H] = +0.39$. The overall uncertainty, resulting from the measured equivalent widths and the adopted atmospheric parameters, is 0.15–0.20 dex, so we may assume for NGC 6253: $[Fe/H] = +0.36 \pm 0.20$ dex. This is in very good agreement with the photometric study and with the value found by Piatti et al. (1998) from integrated spectra. NGC 6253 appears in Figure 1 (high resolution panel) as the innermost cluster of the whole sample, and its metallicity conforms to the Galactocentric gradient found for the other clusters.

We have recently acquired spectra of better quality of the same stars in NGC 6253, and we plan to analyze them to derive the abundances of

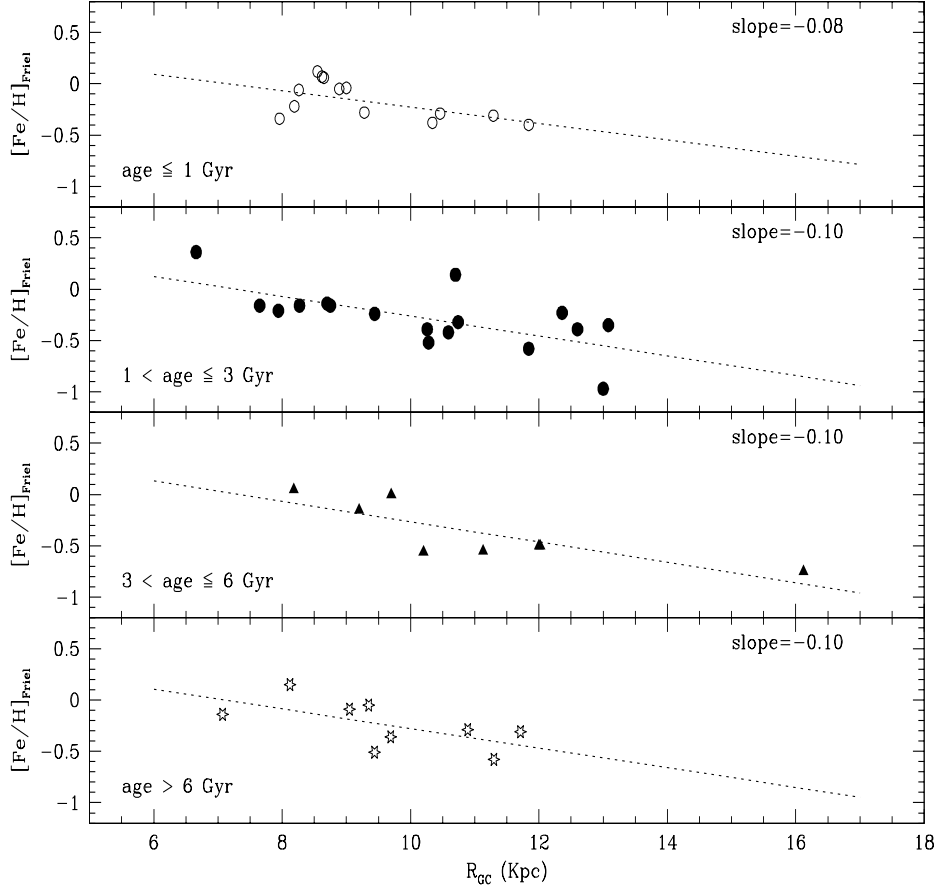


Figure 2. Run with Galactocentric distance of the observed metallicity (as derived by Friel 1995) for open clusters, divided into four age bins.

other elements. Our plan for the next future is to obtain high-resolution spectra in several open clusters in order to derive accurate and homogenous metallicities of a large sample of clusters. This is a prerequisite for a really meaningful study of the history of the chemical enrichment of the Galactic disk.

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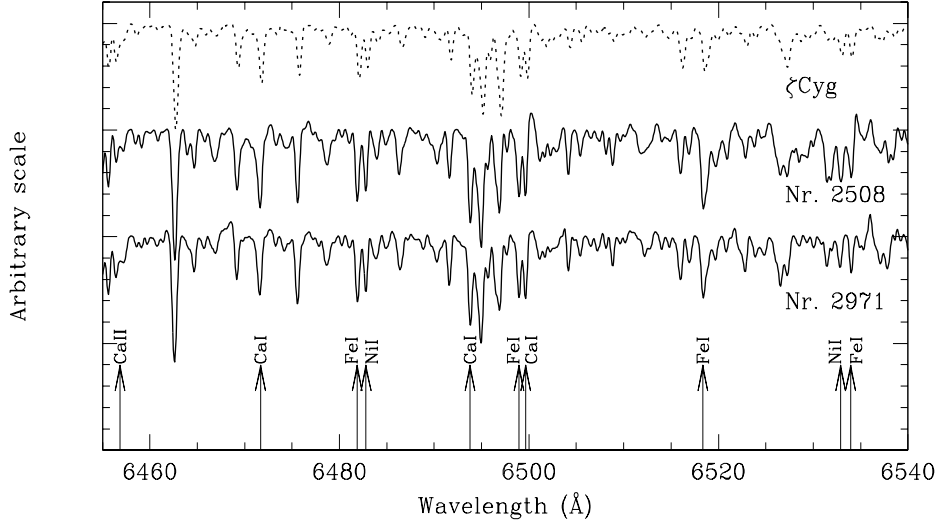


Figure 3. A region of the normalized spectra of the two NGC 6253 stars, compared to ζ Cyg: notice the shallower lines of the latter, indicative of a slightly lower metal content; the spectra have been arbitrarily shifted for clarity.

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